



Approaching target: A service for nationwide deformation monitoring in Denmark using Sentinel-1

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Advances in the Science and Applications of SAR Interferometry and Sentinel-1 InSAR

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Approaching target: A service for nationwide
deformation monitoring in Denmark using Sentinel-1

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Why? Motivation



What? Activities



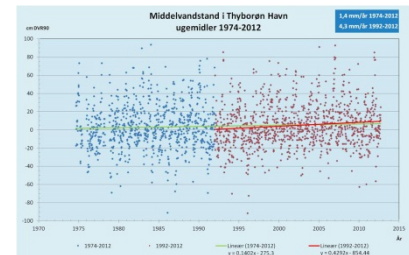
...and then what? Road map

The "why": Motivation

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- Small country w/ low topography
- Issues:
 - Climate changes
 - Management of levels
 - Soil management
 - Coastal urbanisation
- Vertical ground motion
 - Imminent risk of
 - Broken pipes
 - Explosion of pipes
 - ...

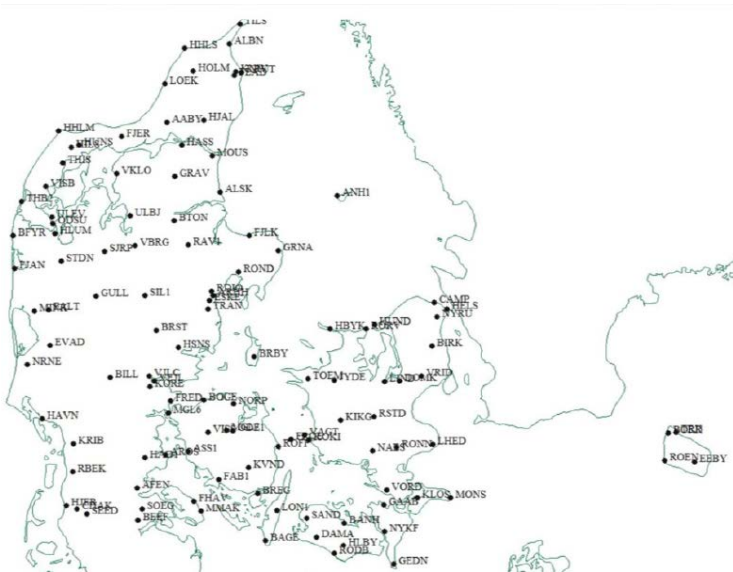
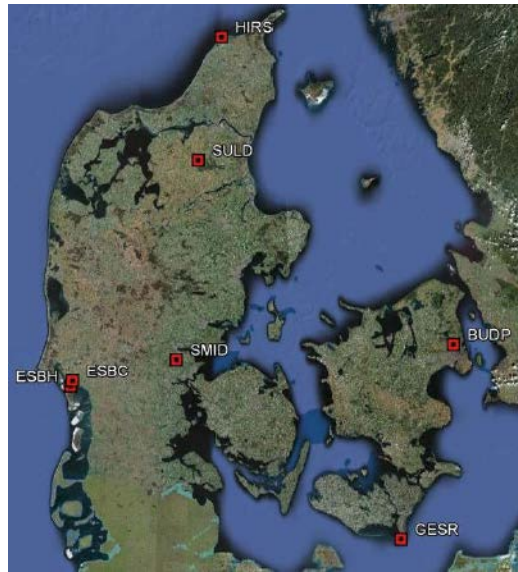
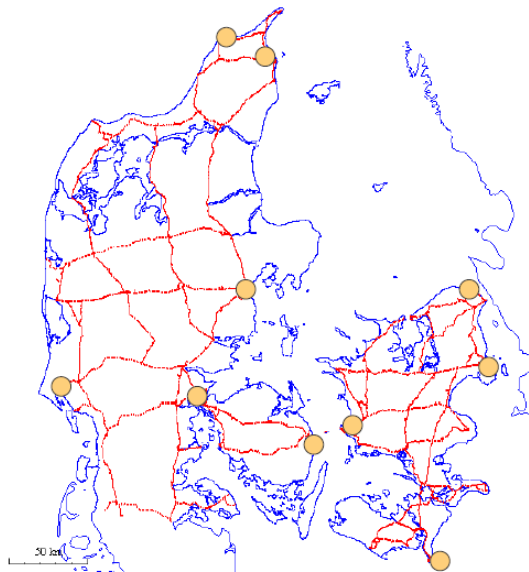


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The "why": Need for deformation monitoring

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Long-term experience with: Precision leveling + GNSS



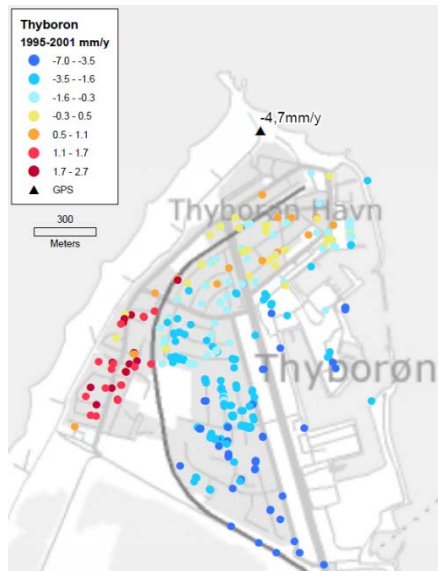
Precision leveling (1885→):
Cycles of 1 yr, 3 yrs, 50 yrs

GNSS: Permanent (1998→) as well as semi-permanent (2007→) stations
with cycles of 1 yr, 3 yrs

The "why": Need for deformation monitoring

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Long-term experience with: InSAR



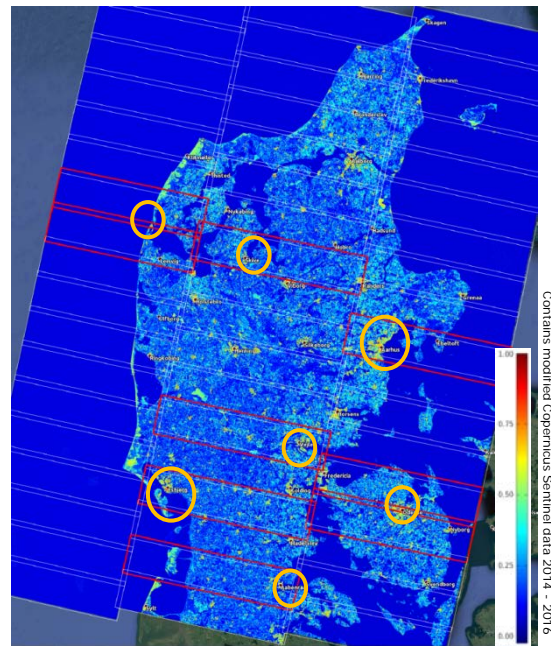
ERS-2 (1995-2001)

Various test studies with ERS, EV, S1 data.

Activities:

- QC over selected sites
- Build up experience
- Demonstrate potentials

Optimal climate change adaptation ↔ high spatial coverage + hotspot detection: possible with InSAR, particularly Sentinel-1!



Ref: PPO.Labs, NORUT, NGU (2017)

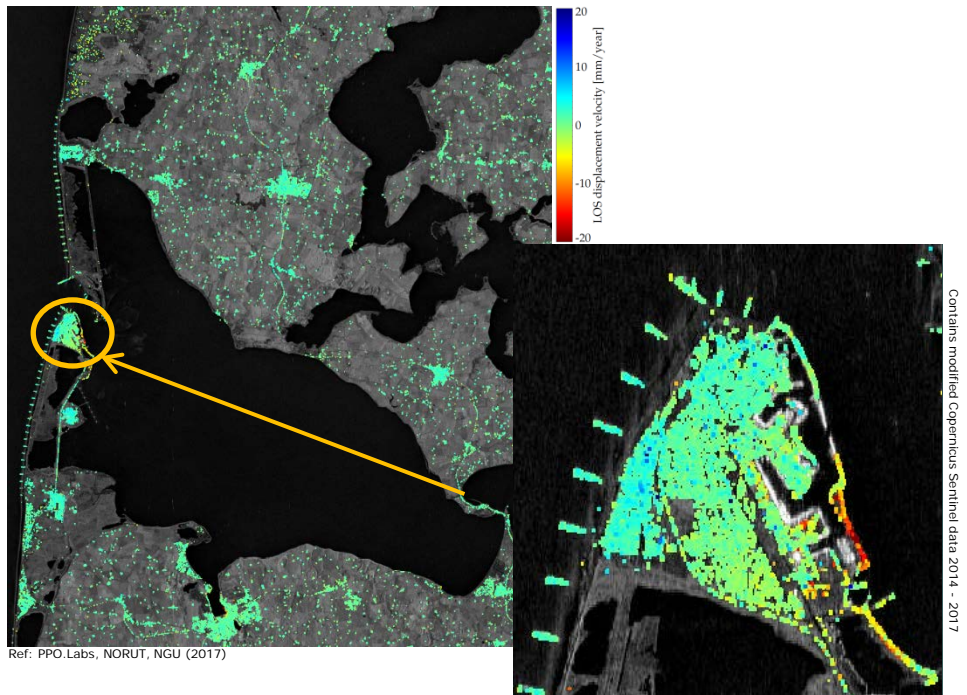
Summary:

- Imminent risk of flooding.
- InSAR ideal screening tool.

Copernicus program:

- Sentinel-1: High spatio-temporal resolution and spatial coverage.
- Data acquisition ensured until 2030.
- Free and open data policy.

→ Great potential for nationwide deformation monitoring!

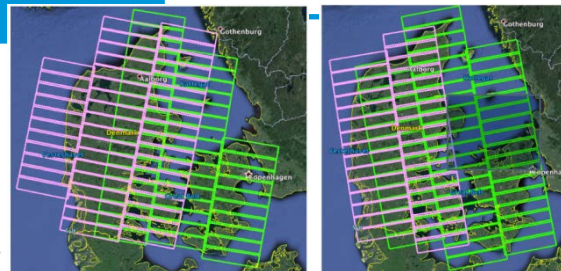


Requirements for establishing operational service for nationwide deformation monitoring in Denmark?

Process:

How? Identify technical approach (status: completed)

- Which technique is optimal for DK, and why?
- How to update, and why?
- How to include leveling, GNSS, corner reflectors?
- How to expand network of corner reflectors?
- Costs for service?
- Processing: Esbjerg, Aarhus, **first large-scale deformation map.**



Why? Identify end-user requirements (status: on-going)

- Point density? Error estimate? Data format? Type of visualisation? ...?

How much? Cost-benefit analyses (status: on-going)

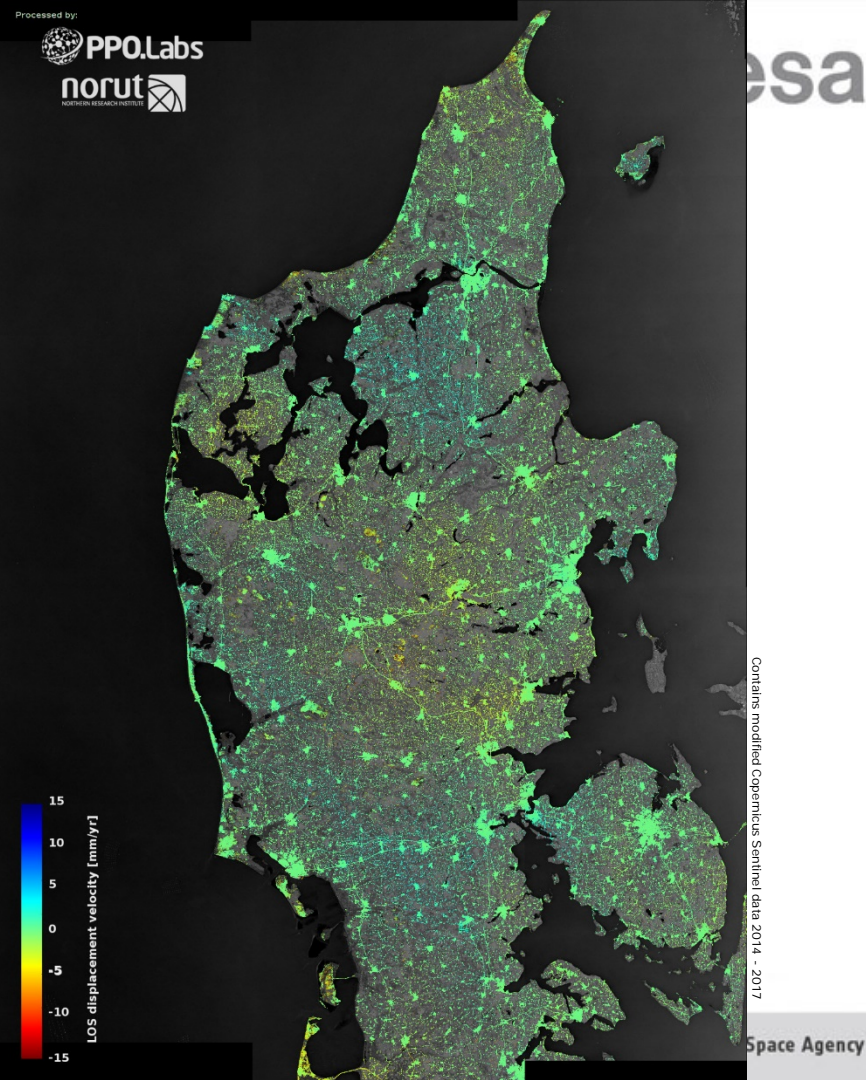
When? Basis of decision (status: November)

- If yes: EU tender (2018)

The "what": Results

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- Integration of multitude of methods
 - PSI and SBAS
 - Utilisation of all relevant geometries
 - On-going R&D to resolve long-wavelength components: GIA signal and seasonal signal
 - Preliminary, large-scale result:
 - PSI: Oct. 2014 – Mar. 2017
 - Most infrastructure resolved
 - Islands and mainland well-connected
 - Expected errors: ± 3 mm/yr
- En route to nationwide solution



The "what": Results

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Platform for dissemination

- Web-interface essential
- Must be profiled to end-user needs

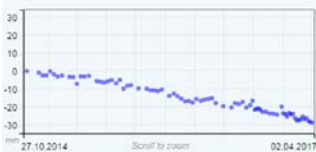
Work-in-progress!



Thyboron (Tr 139D Th 065)

Sampling 274 points over approx. 0.062km²

grid 90394.35	easting 452571.55	northing 6283781.01
long 8.22	height 37.69	vel_mean -11.51
vel_vert -15.68	vel_alo -15.68	coh 0.79
ampdep 0.37	pixrel 7266.33	line 1422.9
inc_angle 42.78	tr_angle -170.58	los_east -0.67
los_north 0.11	los_up -0.74	

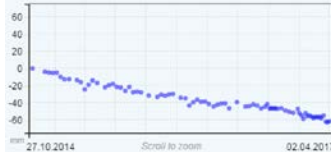


Ref: PPO.Labs, NORUT, NGU (2017)



Thyboron (Tr 139D Th 065)

grid 96006	easting 452607.34	northing 6283681.58
long 8.22	height 36.5	vel_mean -21.63
vel_vert -29.33	vel_alo -29.33	coh 0.8
ampdep 0.36	pixrel 7248	line 1434
inc_angle 42.78	tr_angle -170.58	los_east -0.67
los_north 0.11	los_up -0.74	



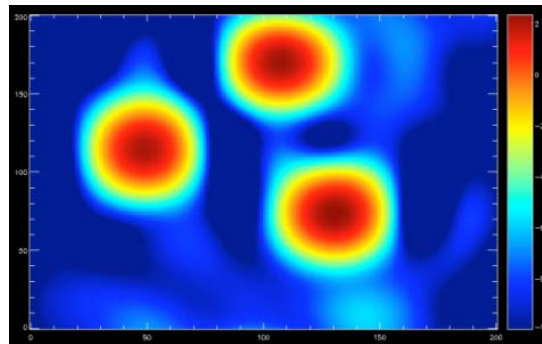
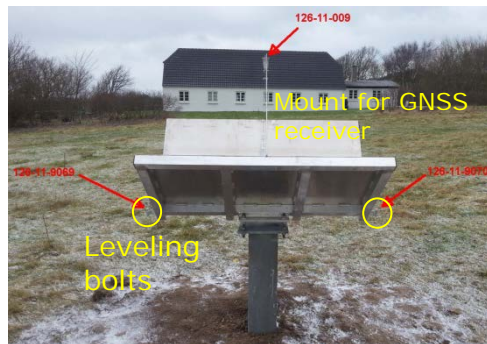
Contains modified Copernicus Sentinel data 2014 - 2017



European Space Agency

Corner reflectors

- Test and permanent set-ups
- Quality control
- Demonstration
- Integration
- Geo-referencing



Q: How did DK make it this far?

A: The possibility to establish operational services →

Cross-border collaborations

- Simple to confine AOI and avoids multiple, cross-border computations (ex: SNGMS).
- Exploitation of regions facing similar issues (ex: climate changes).
- Exploitation of other countries' expertise/ knowledge.

Maximising output

- Inclusion of potential end-users to specify technical requirements

Thank you!

The presentation contains modified Copernicus Sentinel data 2014-2017

The authors would like to acknowledge ESA and the Copernicus programme for making data available, and PPO.Labs, NORUT, and NGU for processing and expert advice.